NRI research highlights

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Ethylene Gas as a Modulator of Plant Growth and Development

Harry J. Klee, The University of Florida

Ethylene gas is widely used in agriculture because of its unique and powerful role as a regulator of many aspects of plant growth and development. Many people are familiar, for example, with the role of ethylene gas as a ripening (or "degreening") agent for tomatoes and bananas.

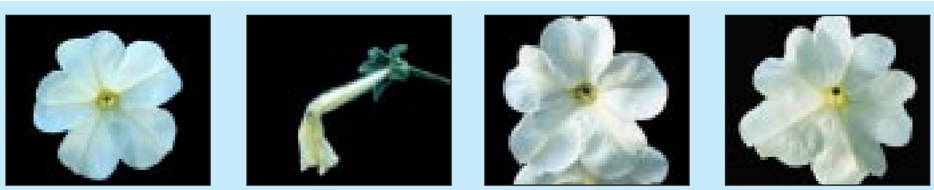
Ethylene's actions on plants, however, also can be undesirable. For example, ethylene gas is the causative agent in many postharvest disorders of horticultural commodities. It causes premature senescence of many tissues, as evidenced by petal wilting or dropping in flowers such as carnations, geraniums, and petunias.

Wide-ranging effects, both positive and negative, can occur because ethylene is by definition a plant hormone. The gas is synthesized by a plant in response to a variety of developmental and environmental cues, binds to one or more of a family of specific receptors, and initiates a series of complex biochemical events.

Despite the immense importance of ethylene to plants, very little is known about how this hormone is perceived by the plant. However, with funding from the National Research Initiative (NRI) Competitive Grants Program, we have begun a molecular and genetic study of the family of ethylene receptors.

Research on ethylene perception has proceeded on three fronts. First, we have identified and characterized the gene family for ethylene receptors in tomatoes. Second, we have used a mutant in one of the receptors to clarify the role of ethylene in a variety of developmental processes. Third, we have built upon our knowledge of the receptor genes from tomatoes and the model plant species *Arabidopsis* to engineer plants with improved horticultural properties.

Concurrent with characterization of the family of ethylene receptors, we have used



Day 0 — Day 3 — Day 0 — Day 8

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Control flower — Transgenic flower

Effect of ethylene insensitivity on pollinated petunia flowers. The control flower is wilted on Day 3, but the ethylene-insensitive flower still looks fresh on Day 8.

Directed control of ethylene insensitivity may reduce the severity of certain plant diseases.

an ethylene-insensitive mutant to assist in understanding the role of ethylene perception in growth and development. Recent research has focused on one particular stress: disease-causing pathogenic microbes. In our studies of three organisms known to cause disease on tomatoes, we found that ethylene perception was critical to the spread of disease symptoms following initial infection. Plants that could not perceive ethylene were not nearly as diseased as those that could.

These results have significance for the future genetic manipulation of horticultural crops. Our current efforts are aimed at understanding the role of ethylene in disease symptom development. Through directed control of ethylene insensitivity, we hope to be able to reduce the severity of certain plant diseases.

Finally, we have been very interested in applying our fundamental knowledge of ethylene to improvement of horticultural commodities. Mutant ethylene receptors, which no longer bind ethylene, act as single, dominant genes. It is not known precisely how the mutant receptors can confer dominant ethylene insensitivity on plants, but it is clear that they do.

An early research question was whether we could transfer these mutant genes from one species to another and use them to confer ethylene insensitivity on new plants. For example, could we genetically engineer a mutant *Arabidopsis* gene into a petunia plant and make that plant ethylene-insensitive? The answer is yes. We introduced both *Arabidopsis* and tomato mutant genes into a variety of species, including petunias, and produced several new ethylene-insensitive plants.

The petunias are particularly interesting. When a petunia flower is pollinated, it produces ethylene within 1 hour. This burst of ethylene synthesis is a signal to the flower that successful pollination has occurred, and the flower responds by initiating corolla (petal) wilting. Within 36 hours, the corolla is completely wilted, and it drops. In the transgenic plants, however, wilting does not occur. Flower life is extended from less than 2 days to well over a week (see illustration, reverse page).

Many important floricultural crops (e.g., carnations and geraniums) have the same physiology as petunias, and engineering these species for ethylene insensitivity is likely to lead to the same outcome. The demonstration that fundamental research on plants' perception of ethylene can have a real impact on applied horticulture is very exciting. There is every reason to believe that this NRI-funded research will lead not only to a better fed world through reduction of postharvest food losses but to a prettier world of longer lasting flowers as well. ❖

The research reported in this factsheet was sponsored by the Plant Growth and Development Program of the National Research Initiative Competitive Grants Program. To be placed on the mailing list for this publication or to receive additional information, please contact the NRI (202/401-5022 or NRICGP@reeusda.gov). The factsheet also is accessible on the CSREES home page (http://www.reeusda.gov/nri).

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